Superconducting properties of a Sn layer with embedded magnetic Co clusters

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When embedding ferromagnetic nanoparticles in a superconducting matrix, a direct contact between the superconductor and ferromagnet is enabled resulting in a nanoscale magnetic modulation. The aim here is to study to what extent superconductivity and ferromagnetism can coexist and mutually influence each other.

Preformed Co clusters with typical diameters around 2 nm are produced with a laser-vaporization cluster source and have been co-deposited with thermally evaporated Sn on liquid nitrogen cooled SiO_2-substrates. This way, different hybrid systems consisting of magnetic clusters randomly distributed in a superconducting Sn matrix were produced with increasing concentration of Co clusters up to 30 volume percent. Structural characterization of the samples has been done by means of atomic force microscopy, Rutherford backscattering spectrometry and X-ray diffraction. The magnetic and superconducting behaviour of these systems was studied by SQUID magnetometry measurements.

The magnetic behaviour of the Co clusters varies from superparamagnetic to ferromagnetic with increasing amount of embedded Co clusters. For Co concentrations below 20 volume percent, the Co clusters are superparamagnetic, revealing reversible magnetization curves at temperatures above 100K. For higher concentrations of Co, the Co clusters interact with each other and behave as ferromagnetic particles up to 300K. In both regimes, the hybrid Co/Sn systems show superconducting behaviour. The superconducting critical temperature and phase boundary are investigated for different concentrations of Co clusters.

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